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TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
1. Performance											
a. Engine Assessment											
(1) Start Operations											
a) Engine start and acceleration (transient).	Light Off Time - ±10% or ±1 sec. Torque - ±5% Rotor Speed - ±3% Fuel Flow -±10% Gas Generator Speed - ±5% Power Turbine Speed - ±5% Gas Turbine Temp. - ±30°C	Ground with the Rotor Brake Used and Not Used			X			X	Record each engine start from the initiation of the start sequence to steady state idle and from steady state idle to operating RPM.		.
(b) Steady State Idle and Operating RPM conditions.	Torque - ±3% Rotor Speed - ±1.5% Fuel Flow - ±5% Gas Generator Speed - ±2% Power Turbine Speed - ±2% Turbine Gas Temp. - ±20°C	Ground		X	X		X	X	Record both steady state idle and operating RPM conditions. May be a series of snapshot tests.		
(2) Power Turbine Speed Trim	±10% of total change of power turbine speed.	Ground			X			X	Record engine response to trim system actuation in both directions.		

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			1	2	3	4	5	6		
(3) Engine and Rotor Speed Governing	Torque - ±5% Rotor Speed - ±1.5%	1) Climb 2) Descent			X			X	Record results using a step input to the collective. May be conducted concurrently with climb and descent performance tests.	
b. In Flight										
Performance and Trimmed Flight Control Positions.	Torque - ±3% Pitch Attitude - ±1.5º Sideslip Angle - ±2º Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	Cruise (Augmentation On and Off)		X	X		X	X	Record results for two gross weight and CG combinations with varying trim speeds throughout the airspeed envelope. May be a series of snapshot tests.	
c. Climb										
Performance and Trimmed Flight Control Positions.	Vertical Velocity - ±100 fpm (61m/sec) or ±10% Pitch Attitude - ±1.5º Sideslip Angle - ±2º Longitudinal Control Position - ±5% Lateral Control	All engines operating. One engine inoperative. Augmentation System(s) On and		X	X		X	X	Record results for two gross weight and CG combinations. The data presented must be for normal climb power conditions. May be a series of snapshot tests.	

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			1	2	3	4	5	6			
	Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	Off									
d. Descent.											
(1) Descent Performance and Trimmed Flight Control Positions.	Torque - ±3% Pitch Attitude - ±1.5º Sideslip Angle - ±2º Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	At or near 1,000 fpm rate of descent (RoD) at normal approach speed. Augmentation System(s) On and Off		X	X		X	X	Record results for two gross weight and CG combinations. May be a series of snapshot tests.		
(2) Autorotation Performance and Trimmed Flight Control Positions.	Torque - ±3% Pitch Attitude - ±1.5º Sideslip Angle - ±2º Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	Steady descents. Augmentation System(s) On and Off		X	X		X	X	Record results for two gross weight conditions. Data must be recorded for normal operating RPM. (Rotor speed tolerance applies only if collective control position is full down.) Data must be recorded for speeds from approximately 50 kts.		

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
									through at least maximum glide distance airspeed. May be a series of snapshot tests.		
e. Autorotation.											
Entry**.**	Rotor Speed - ±3% Pitch Attitude ±2º Roll Attitude - ±3º Yaw Attitude - ±5º Airspeed - ±5 kts. Vertical Velocity - ±200 fpm (1.00 m/sec) or 10%	1) Cruise; or 2) Climb			**X**			**X**	Record results of a rapid throttle reduction to idle. If accomplished in cruise, results must be for the maximum range airspeed. If accomplished in climb, results must be for the maximum rate of climb airspeed at or near maximum continuous power.		
2. Handling Qualities.											
a. Control System Mechanical Characteristics.											
For FTDs requiring Static or Dynamic tests at the controls (i.e., cyclic, collective, and pedal), special test fixtures will not be											Contact the NSPM

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
required during initial or upgrade evaluations if the sponsor's QTG/MQTG shows both test fixture results **and** the results of an alternative approach, such as computer plots produced concurrently, that show satisfactory agreement. Repeat of the alternative method during the initial or upgrade evaluation would then satisfy this test requirement. For initial and upgrade evaluations, the control dynamic characteristics must be measured at and recorded directly from the cockpit controls, and must be accomplished in climb, cruise, and autorotation.											for clarification of any issue regarding helicopters with reversible controls.
(1) Cyclic	Breakout - ±0.25 lbs. (0.112 daN) or 25%. Force - ±1.0 lb. (0.224 daN) or 10%.	Ground; Static conditions. Trim On and Off. Friction Off Augmentation On and .ff		X	X		X	X	Record results for an uninterrupted control sweep to the stops. [This test does not apply if aircraft hardware modular controllers are used.]		
(2) Collective and Pedals	Breakout - ±0.5 lb. (0.224 daN) or 25%. Force - ±1.0 lb. (0.224 daN) or 10%.	Ground; Static conditions. Trim On and Off. Friction Off Augmentation On and Off.		X	X		X	X	Record results for an uninterrupted control *sweep* to the stops.		
(3) Brake Pedal Force vs. Position.	±5 lbs. (2.224 daN) or 10%	Ground; Static conditions.		X	X		X	X			
(4) Trim System Rate (all applicable systems)	Rate - ±10%	Ground; Static conditions. Trim On Friction Off		X	X		X	X	The tolerance applies to the recorded value of the trim rate.		
(5) Control Dynamics (all axes)	±10% of time for first zero crossing and ±10 (N+1)% of period thereafter. ±10% of amplitude of	Hover/Cruise Trim On Friction Off						X	Results must be recorded for a normal control displacement in both directions in each axis (approximately		Control Dynamics for irreversible control systems may be evaluated in a ground/static

TABLE OF VALIDATION TESTS

TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL 1	2	3	4	5	6	TEST DETAILS	INFORMATION NOTES
	first overshoot. ±20% of amplitude of 2^{nd} and subsequent overshoots greater than 5% of initial displacement. ±1 overshoot.								25% to 50% of full throw).	condition. Refer to paragraph 3 of this attachment for additional information. "N" is the sequential period of a full cycle of oscillation.
(6) Freeplay	±0.10 in.	Ground; Static conditions.		X	X		X	X	Record and compare results for all controls..	
b. Longitudinal Handling Qualities.										
(1) Control Response	Pitch Rate - ±10% or ±2º/sec. Pitch Attitude Change - ±10% or ±1.5º.	Cruise Augmentation On and Off.		X	X		X	X	Results must be recorded for two cruise airspeeds to include minimum power required speed. Record data for a step control input. The Off-axis response must show correct trend for unaugmented cases.	
(2) Static Stability	Longitudinal Control Position: ±10% of change from trim or ±0.25 in. (6.3 mm) or Longitudinal Control Force : ±0.5 lb. (0.223	Cruise or Climb. Autorotation. Augmentation On and Off.		X	X		X	X	Record results for a minimum of two speeds on each side of the trim speed. May be a series of snapshot tests.	

TABLE OF VALIDATION TESTS										
										INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS	NOTES
			1	2	3	4	5	6		
	daN) or ±10%.									
(3) Dynamic Stability										
(a) Long Term Response.	±10% of calculated period. ±10% of time to ½ or double amplitude, or ±0.02 of damping ratio.	Cruise Augmentation On and Off.		X	X		X	X	Record results for three full cycles (6 overshoots after input completed) or that sufficient to determine time to ½ or double amplitude, whichever is less. For non-periodic responses, the time history must be matched.	
(b) Short Term Response.	±1.5º Pitch or ±2º/sec. Pitch Rate. ±0.1 g Normal Acceleration.	Cruise or Climb. Augmentation On and Off.						X	Record results for at least two airspeeds.	
(4) Maneuvering Stability.	Longitudinal Control Position - ±10% of change from trim or ±0.25 in. (6.3mm) or Longitudinal Control Forces - ±0.5 lb. (0.223 daN) or ±10%.	Cruise or Climb. Augmentation On and Off.						X	Record results for at least two airspeeds. Record results for Approximately 30º-45º bank angle. The force may be shown as a cross plot for irreversible systems.	

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
									May be a series of snapshot tests.		
(5) Landing Gear Operating Times	±1 sec.	Takeoff (Retraction) Approach (Extension)		X	X		X	X			
c. Lateral and Directional Handling Qualities.											
(1)Control Response.											
(a) Lateral	Roll Rate - ±10% or ±3º/sec. Roll Attitude Change - ±10% or ±3º.	Cruise Augmentation On and Off.		X	X		X	X	Record results for at least two airspeeds, including the speed at or near the minimum power required airspeed. Record results for a step control input. The Off-axis response must show correct trend for unaugmented cases.		
(b) Directional	Yaw Rate - ±10% or ±2º/sec. Yaw Attitude Change -	Cruise Augmentation On and Off.		X	X		X	X	Record data for at least two Airspeeds, including the speed at		

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
	±10% or ±2º.								or near the minimum power required airspeed. Record results for a step control input. The Off-axis response must show correct trend for unaugmented cases.		
(2) Directional Static Stability.	Lateral Control Position - ±10% of change from trim or ±0.25 in. (6.3mm) or Lateral Control Force - ±0.5 lb. (0.223 daN) or 10%. Roll Attitude - ±1.5 Directional Control Position - ±10% of change from trim or ±0.25 in. (6.3mm) or Directional Control Force - ±1 lb. (0.448 daN) or 10%. Longitudinal Control Position - ±10% of change from trim or ±0.25 in. (6.3mm). Vertical Velocity - ±100 fpm (0.50m/sec)	1) Cruise; or 2) Climb (may use Descent instead of Climb if desired) Augmentation On and Off.		X	X		X	X	Record results for at least two sideslip angles on either side of the trim point. The force may be shown as a cross plot for irreversible systems. May be a series of snapshot tests.		This is a steady heading sideslip test.

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
	or 10%.										
(3) Dynamic Lateral and Directional Stability											
(a) Lateral-Directional Oscillations.	±0.5 sec. or ±10% of period. ±10% of time to ½ or double amplitude or ±0.02 of damping ratio. ±20% or ±1 sec of time difference between peaks of bank and sideslip.	Cruise or Climb Augmentation On/Off		X	X		X	X	Record results for at least two airspeeds. The test must be initiated with a cyclic or a pedal doublet input. Record results for six full cycles (12 overshoots after input completed) or that sufficient to determine time to ½ or double amplitude, whichever is less. For non-periodic response, the time history must be matched.		
(b) Spiral Stability	Correct Trend, ±2º bank or ±10% in 20 sec.	Cruise or Climb. Augmentation On and Off.		X	X		X	X	Record the results of a release from pedal only or cyclic only turns. Results must be recorded from turns in both directions.		

TABLE OF VALIDATION TESTS											
											INFORMATION
TEST	TOLERENCE	FLIGHT CONDITIONS	Flight Training Device LEVEL						TEST DETAILS		NOTES
			1	2	3	4	5	6			
(c) Adverse / Proverse Yaw	Correct Trend, ±2º transient sideslip angle.	Cruise or Climb. Augmentation On and Off.		X	X		X	X	Record the time history of initial entry into cyclic only turns, using only a moderate rate for cyclic input. Results must be recorded for turns in both directions.		

3. Control Dynamics.

a. The characteristics of a helicopter flight control system have a major effect on the handling qualities. A significant consideration in pilot acceptability of a helicopter is the “feel” provided through the cockpit controls. Considerable effort is expended on helicopter feel system design in order to deliver a system with which pilots will be comfortable and consider the helicopter desirable to fly. In order for an FTD to be representative, it too must present the pilot with the proper feel; that of the respective helicopter.

b. Recordings such as free response to an impulse or step function are classically used to estimate the dynamic properties of electromechanical systems. In any case, it is only possible to estimate the dynamic properties as a result of only being able to estimate true inputs and responses. Therefore, it is imperative that the best possible data be collected since close matching of the FTD control loading system to the helicopter systems is essential. Control feel dynamic tests are described in the Table of Objective Tests in this attachment. Where accomplished, the free response is measured after a step or pulse input is used to excite the system.

c. For initial and upgrade evaluations, it is required that control dynamic characteristics be measured at and recorded directly from the cockpit controls. This procedure is usually accomplished by measuring the free response of the controls using a step or pulse input to excite the system. The procedure must be accomplished in hover, climb, cruise, and autorotation. For helicopters with irreversible control systems, measurements may be obtained on the ground. Proper pitot-static inputs (if appropriate) must be provided to represent airspeeds typical of those encountered in flight.

d. It may be shown that for some helicopters, climb, cruise, and autorotation have like effects. Thus, some tests for one may suffice for some tests for another. If either or both considerations apply, engineering validation or helicopter manufacturer rationale must be submitted as justification for ground tests or for eliminating a configuration. For FTDs requiring static and dynamic tests at the controls, special test fixtures will not be required during initial and upgrade evaluations if the sponsor's QTG shows both test fixture results and the results of an alternative approach, such as computer plots which were produced concurrently and show satisfactory agreement. Repeat of the alternative method during the initial evaluation would then satisfy this test requirement.

e. Control Dynamics Evaluations. The dynamic properties of control systems are often stated in terms of frequency, damping, and a number of other classical measurements which can be found in texts on control systems. In order to establish a consistent means of validating test results for FTD control loading, criteria are needed that will clearly define the interpretation of the measurements and the tolerances to be applied. Criteria are needed for both the underdamped system and the overdamped system, including the critically damped case. In the case of an underdamped system with very light damping, the system may be quantified in terms of frequency and damping. In critically damped or overdamped systems, the frequency and damping is not readily measured from a response time history. Therefore, some other measurement must be used.

f. Tests to verify that control feel dynamics represent the helicopter must show that the dynamic damping cycles (free response of the control) match that of the helicopter within specified tolerances. The method of evaluating the response and the tolerance to be applied are described below for the underdamped and critically damped cases.

g. Tolerances.

(1) Underdamped Response.

(i) Two measurements are required for the period, the time to first zero crossing (in case a rate limit is present) and the subsequent frequency of oscillation. It is necessary to measure cycles on an individual basis in case there are nonuniform periods in the response. Each period will be independently compared to the respective period of the helicopter control system and, consequently, will enjoy the full tolerance specified for that period.

(ii) The damping tolerance will be applied to overshoots on an individual basis. Care must be taken when applying the tolerance to small overshoots since the significance of such overshoots becomes questionable. Only those overshoots larger than 5 percent of the total initial displacement will be considered significant. The residual band, labeled $T(A_d)$ on Figure 1 is ±5 percent of the initial displacement amplitude A_d from the steady state value of the oscillation. Oscillations within the residual band are considered insignificant. When comparing simulator data to helicopter data, the process would begin by overlaying or aligning the simulator and helicopter steady state values and then comparing amplitudes of oscillation peaks, the time of the first zero crossing, and individual periods of oscillation. To be satisfactory, the simulator must show the same number of significant overshoots to within one when compared against the helicopter data. This procedure for evaluating the response is illustrated in Figure 1

(2) Critically Damped and Overdamped Response. Due to the nature of critically damped responses (no overshoots), the time to reach 90 percent of the steady state (neutral point) value must be the same as the helicopter within ±10 percent. The simulator response must be critically damped also. Figure 2 illustrates the procedure.

(3) The following summarizes the tolerances, T, for an illustration of the referenced measurements. (See Figures 1 and 2, above)

$T(P_0)$ ±10% of P_0
$T(P_1)$ ±20% of P_1
$T(A)$ ±10% of A_1, ±20% of Subsequent Peaks
$T(A_d)$ ±10% of A_d = Residual Band
Overshoots ±1

In the event the number of cycles completed outside of the residual band, and thereby significant, exceeds the number depicted in figure 1, the following tolerances (T) will apply:

$T(P_n)$ ±10%(n+1)% of P_n, where "n" is the next in sequence.

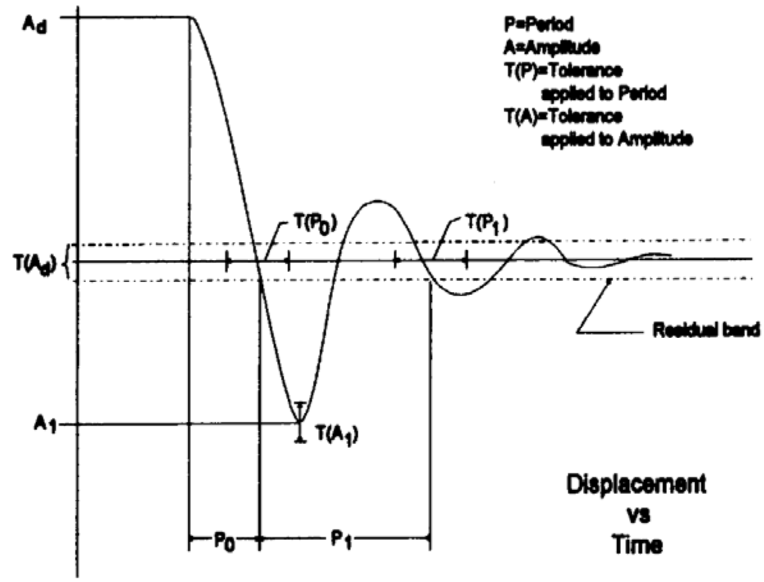

FIGURE 1. UNDER-DAMPED STEP RESPONSE

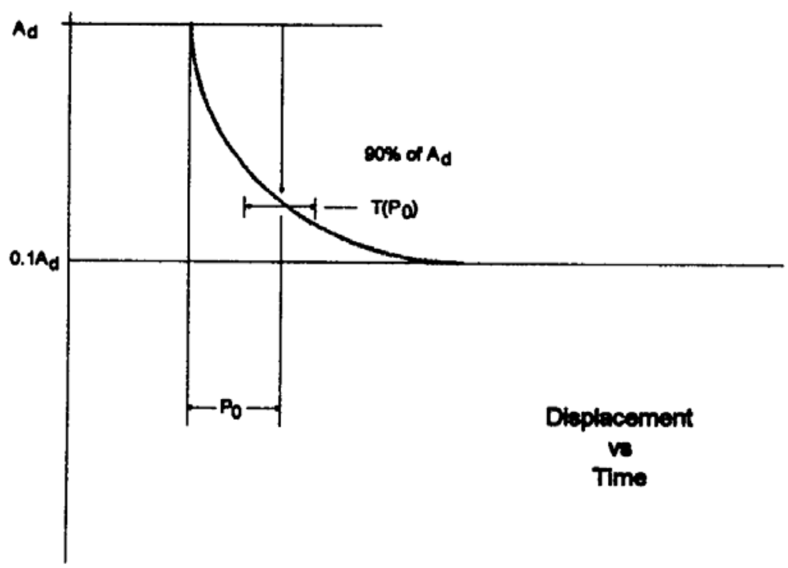

FIGURE 2. CRITICALLY-DAMPED STEP RESPONSE